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(54) **Micro-electromechanical structure insensitive to mechanical stresses.**

(57)   A microelectromechanical structure (40) includes a rotor element (22) having a barycentric axis (G) and suspended regions (25) arranged a distance with respect to the barycentric axis. The rotor element (22) is supported and biased via a suspension structure (30, 45, 49) having a single anchoring portion (49) extending along the barycentric axis (G). The single anchoring portion (49; 73; 92) is integral with a body (41) of semiconductor material on which electric connections (50a) are formed.
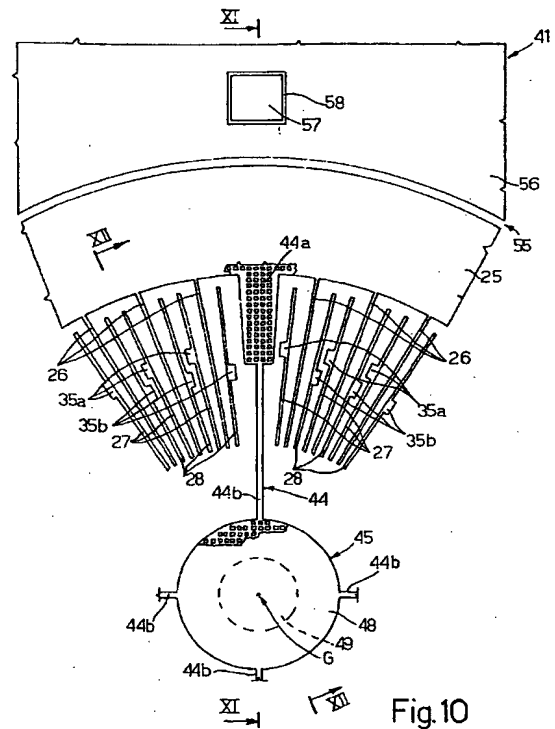
Fig.10

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Fig.11

Description

[0001]   The present invention regards a micro-electro-mechanical structure insensitive to mechanical stresses.

[0002]   As known, surface and epitaxial micromachining techniques allow production of microstructures within a layer that is deposited (for example a polycrystalline silicon film), or grown (for example an epitaxial layer), on sacrificial regions, removed at the end of the manufacturing process, by wet etching.

[0003]   In general, the layers subject to micromachining (deposited or grown layers), are formed at high temperatures, completely different from the operative temperatures. In addition, the various regions forming the end devices have different thermal expansion coefficients. Consequently, at the microstructure operative temperatures, residual mechanical stresses are present; in addition, in particular when the various regions are doped not uniformly, the stresses are not uniform (stress gradients); these stresses thus cause undesirable mechanical deformations of the microstructures, as described schematically hereinafter with reference to figures 1-6.

[0004]   In detail, figure 1 shows in cross-section a structure 1 comprising a polycrystalline silicon bridge element 2, formed on a monocrystalline silicon substrate 3; a sacrificial oxide layer 4 extends between the bridge element 2 and the substrate 3, except for two areas, where anchorage portions 5 of the bridge element 2 extend through the sacrificial oxide layer 4, and are supported directly on the substrate 3.

[0005]   Figure 2 shows the same structure 1 as in figure 1, in plan view.

[0006]   Figures 3 and 4 show the structure 1, after removal of the sacrificial oxide layer 4, when the dimensions of the structure have been reduced (shown exaggerated in the figures, for better understanding), owing to the presence of residual stress; in particular, in figure 3, owing to the different thermal coefficients, the dimensions of the bridge element 2 are reduced (shortened) more than those of the substrate 3; here the bridge element 2 is subjected to tensile stress, and assumes a more favorable energetic configuration. In figure 4 on the other hand, the bridge element 2 undergoes a lesser reduction of dimensions than the substrate 3; consequently, in this condition, the bridge element 2 tends to be lengthened in comparison with the substrate 3, but, owing to the fixed anchorage portions 5, it undergoes stress of a compressive type, causing buckling deformation.

[0007]   In the case of tensile stress, the mechanical resonance frequency of bridge element 2 is shifted upwards with respect to the intrinsic value (in the absence of stress); on the other hand, in the case of compressive stress, the mechanical resonance frequency of the bridge element 2 is shifted downwards.

[0008]   The average residual stress thus has the effect of modifying the resilient constant of the micromechanical structures; this modification is not reproducible, and can cause mechanical collapse of the structure (in particular in the case in figure 4).

[0009]   In figure 5, the projecting element 11 is formed on a monocrystalline silicon substrate 12; a sacrificial oxide layer 13 extends between the projecting element 11 and the substrate 12, except for an area, where an anchorage portion 14 of the projecting element 11 extends through the sacrificial oxide layer 13, and is supported directly on the substrate 12.

[0010]   Figure 6 shows the structure 10 of figure 5, after removal of the sacrificial oxide layer 13. As can be seen, the release of the residual stress gradient causes the projecting element 11 to flex. In particular, indicating with $\sigma R(z)$ the function linking the residual stress with the coordinate z in the projecting element 11, $\bar{\sigma}_R$ the average residual stress, Γ the strain gradient, and E Young's modulus, the following is obtained:

$$\sigma_R(z) = \bar{\sigma}_R + \Gamma E z$$

[0011]   In addition, indicating with L the length of the projecting element 11, flexure at its free end is independent from the thickness, and is:

$$H = \Gamma L^2 / 2$$

[0012]   Consequently, a positive strain gradient Γ causes the projecting element 11 to bend away from the substrate 12 (upwards), whereas a negative gradient causes it to bend downwards.

[0013]   In case of suspended masses, the behavior is exactly the opposite, i.e. positive stress gradients cause downward flexing, and negative stress gradients give rise to upward flexing.

[0014]   In addition, the material of the package has a different coefficient of thermal expansion as compared to the material of the micromechanical structure (mono- or polycrystalline silicon). Consequently, the suspended masses may be subject to small displacements with respect to the fixed regions of the micromechanical structure.

[0015]   The presence of residual stresses inherent to the structural material and stresses induced by the packaging material jeopardizes the performance of integrated micro-electromechanical devices.

[0016]   For example, in the case of integrated micromechanical structures having a suspended mass, or seismic mass, provided with a plurality of anchorage points, the stresses inherently present in the materials or induced by packaging, by acting in a different and non-uniform way on the various anchorage points, causes tension in some parts and compression in other parts, such as to modify the mutual positions of these parts and to generate non-symmetrical geometries of the

structures.

[0017] For example, consider the case of an angular accelerometer with a suspended mass having an annular shape set outside the center of gravity of the suspended mass, so as to have a high moment of inertia and hence a high sensitivity. Such an accelerometer is illustrated schematically in Figure 7 and in detail in Figure 8, showing only one part thereof.

[0018] Figure 7 shows a semiconductor material chip 20 housing an angular accelerometer 21 comprising a rotor 22 and a stator 23. The chip 20 may moreover house circuit components (not shown) for biasing, controlling and processing signals. The angular accelerometer 21 has a barycentric axis G (defined as an axis passing through the center of gravity - not shown) coinciding with the axis of symmetry of the accelerometer. The rotor 22 (which is able to perform micrometric rotations about the barycentric axis G, in such a way that every movement of the rotor is defined by instantaneous vectors perpendicular to the barycentric axis G) comprises a suspended mass 25 having an annular shape concentric to the barycentric axis G and bearing a plurality of mobile electrodes 26 extending radially inwards from the suspended mass 25. Each mobile electrode 26 is associated to two fixed electrodes 27, 28 extending radially, each of which faces a different side of the respective mobile electrode 26. The fixed electrodes 27, 28, forming together the stator 23, in practice define, together with the respective mobile electrodes 26, a plurality of capacitive circuits; namely, all the fixed electrodes 27, arranged on the same side (for example, on the left in the clockwise direction) of the respective mobile electrode 26, form first capacitors, connected in parallel, whilst all the fixed electrodes 28, arranged on the same side (for example, on the right in the clockwise direction) of the respective mobile electrode 26, form second capacitors, connected in parallel. The first capacitor and the second capacitor associated to a same mobile electrode 26 are, instead, connected in series.

[0019] In a per se known manner, any movement of the suspended mass 25 brings about an increase in the capacitance of one of the two capacitors associated to each mobile electrode 26 and a reduction in the capacitance of the other capacitor. Consequently, by appropriately biasing the mobile electrodes 26 and the fixed electrodes 27, 28 and by connecting them to a circuit that measures the capacitance, it is possible to detect any movement of the suspended mass 25 with respect to the stator 23.

[0020] In the accelerometer 21 of Figure 7, the suspended mass is supported and biased by a suspension structure comprising springs 30 and a rotor anchorage region 34. The springs 30 are arranged at 90° with respect to one another and extend radially between sets of mobile electrodes 26 and fixed electrodes 27, 28. In particular, as is better illustrated in the detail of Figure 8, each spring 30 comprises a pair of lateral arms 31 extending radially inwards from the suspended mass

25, at a distance from one another, and connected to one another at their radially inner ends by a cross portion 32. A central arm 33 thus extends radially from the center of the cross portion 32 between the side arms 31 for approximately one half of the length of the side arms 31 and terminates at the rotor anchorage region 34, which is integral with the chip 20. The springs 30 are suspended and hence are deformable as a result of the rotation of the suspended mass 25.

[0021] Figure 8 moreover shows stator anchorage regions 35a, 35b integral with the fixed electrodes 27 and 28, respectively. The stator anchorage regions 35a, 35b have a width greater than the fixed electrodes 27, 28, extend in depth as far as the substrate (in a not shown manner), and protrude on the sides of the fixed electrodes 27, 28 not facing the respective mobile electrodes 26. In figure 8, a trench 38 separates the mobile mass 25 from the rest of the chip 20.

[0022] With the angular accelerometer of Figure 7, the problem arises that residual stresses or stresses linked to the materials and acting on the rotor 22 cause tensions and compressions of the springs 30, deforming the rotor 22 in a non-foreseeable way.

[0023] The angular accelerometer 21 thus presents reduced performance in terms of sensitivity and precision. In addition, the variations in performance are non-uniform on components belonging to different batches and, at times, on components belonging to a same batch.

[0024] The aim of the invention is thus to solve the problem described above.

[0025] According to the present invention, a micro-electromechanical structure is provided, as defined in Claim 1.

[0026] For a better understanding of the present invention, preferred embodiments thereof are described hereinafter, only as nonlimiting examples, with reference to the attached drawings, wherein:

- Figure 1 shows a cross section through a semiconductor material wafer in an intermediate manufacturing step of a first known microintegrated structure;
- Figure 2 is a top view of the item of Figure 1;
- Figures 3 and 4 show top views similar to Figure 2, at the end of the known manufacturing process, in the presence of a first and, respectively, a second stress condition;
- Figure 5 shows a cross section through a semiconductor material wafer in an intermediate manufacturing step of a second known microintegrated structure;
- Figure 6 shows the same cross section as Figure 5, at the end of the known manufacturing process, in presence of a stress condition;
- Figure 7 is a schematic representation of an integrated angular accelerometer of a known type;
- Figure 8 shows an enlarged detail of the acceler-

ometer of Figure 7;

[0027] With reference to Figure 9, an angular accelerometer 40 is integrated in a chip 41 of semiconductor material and has a general structure similar to that of Figure 7. Consequently, the parts of the accelerometer 40 of Figure 9 that are in common with those of the accelerometer 20 of Figure 7 are denoted by the same reference numbers and will not be further described.

[0028] The suspended mass 25 of the angular accelerometer 40 is supported and biased by a suspension structure comprising four springs 44 and a single anchoring element 45. The springs 44 extend radially and are set 90° apart. In particular, the springs 44 extend between the suspended mass 25 and the anchoring element 45, and the latter is arranged concentrically with respect to the suspended mass 25 along the barycentric axis G of the angular accelerometer 40. As shown in detail in Figure 10, the springs 44 preferably comprise a first, outer, portion 44a and a second, inner, portion 44b. The first portion 44a extends for approximately one third of the length of the spring 44, has a width greater than the second portion 44b (which in practice defines the elastic part that is deformed during rotation of the rotor 22), and is preferably perforated, as is the suspended mass 25, to enable releasing of the rotor 22.

[0029] The anchoring element 45 (see also Figures 11 and 12) comprises a cylindrical body 48, which, in its circumferentially outer portion, is perforated to reduce the size of the anchorage and at the bottom has an anchoring portion 49 having a smaller diameter than the cylindrical body 48. The anchoring portion 49, which is made in a single piece with the cylindrical body 48, is contiguous to a first biasing region 50a (see Figure 11), preferably of polycrystalline silicon, which extends above a substrate 51 and is insulated from the latter by an insulating material region 52a, for example silicon dioxide.

[0030] In particular (Figure 11), the first biasing region 50a forms a connection line that extends from beneath the anchoring portion 49 in a radial direction towards the outside of the angular accelerometer 40, passing underneath an annular trench 55 separating the mobile mass 25 from the bulk 56 of the chip 41 and ending underneath a biasing sinker region 57. The biasing sinker region 57 is laterally surrounded by an isolation trench 58 (Figures 10 and 11) and is connected at the top by electric contact, in a per se known manner, shown only schematically in Figure 11.

[0031] In addition, as is shown in Figure 12 and analogously to the first biasing region 50a, a second biasing region 50b and a third biasing region 50c extend above the substrate 51 and are insulated therefrom by insulating material regions 52b and, respectively, 52c, for example of silicon dioxide. In a not shown manner, the biasing regions 50b and 50c extend annularly along two concentric circumferences and are connected with respective stator anchorage regions 35a, 35b of the fixed electrodes 27, 28 respectively, as may be seen in Figure 12 for one fixed electrode 27 only. The biasing regions 50b and 50c are connected to radial lines (not shown) in a way similar to the first biasing region 50a so as to connect the respective stator anchorage regions 35a, 35b with respective contact sinker regions (not shown) similar to the biasing sinker region 57 shown in Figure 11. Furthermore, the biasing regions 50b and 50c are interrupted only at the first biasing region 50a, and, as regards the outer biasing region 50c, at the radial lines connected to the second biasing region 50b.

[0032] An air gap region 60 extends above the substrate 51 and beneath the rotor 22 and the fixed electrodes 35a, 35b, and is interrupted only by the anchoring portion 49 of the anchoring element 45 and by the stator anchorage regions 35a, 35b. Finally, a trench 61 separates the mobile mass 25, the mobile electrodes 26, and the anchoring element 45 from the fixed electrodes 35a, 35b, as well as the fixed electrodes 35a, 35b, from one another.

[0033] The biasing regions 50a-50c are formed starting from a single polysilicon layer deposited on top of an oxide layer and are shaped prior to forming a sacrificial layer which is to be removed for forming the air gap region 60. The operation of removal of the sacrificial layer moreover involves the removal of the underlying oxide layer, expect for the portions arranged underneath the biasing regions 50a-50c and forming the insulating material regions 52a-52c.

[0034] Thus, with the solution illustrated in Figures 9-12, the rotor 22 is supported and biased by the anchoring structure 45, 49, which is concentric with and is passed by the barycentric axis G. Consequently, the angular accelerometer 40 is far less sensitive to residual stresses than the device shown in Figures 7 and 8. In fact, the stress induced by the package at most generates a shift of the mobile mass 25 and does not deform the springs 30, as in the case of structures with a plurality of anchoring elements, which may undergo displacements different from one another, causing deformation of the structure as a whole. Consequently, the present accelerometer presents a far superior performance during the front-end and back-end steps.

[0035] These advantages are achieved without additional costs, in that the present accelerometer only requires a modification at the design level and does not entail additional operations in the fabrication phase.

[0036] The present invention is moreover applicable to micromechanical structures of any type, such as linear accelerometers, in addition to angular ones, oscillators, mechanical filters, and gyroscopes. Examples of a linear accelerometer and, respectively, of a gyroscope according to the present invention are schematically shown in Figures 13 and 14.

[0037] In detail, the linear accelerometer 70 of Figure 13 comprises a pair of seismic masses 71 having a basically rectangular shape and extending parallel to and at a distance from each other, as well as at a distance from the barycentric axis G of the accelerometer. The seismic masses 71 are connected via four springs 72 to a central beam 73, which also has a rectangular shape and extends parallel to the seismic masses 71 in a central position. In detail, the springs 72, which have a reduced width so that they are able to undergo deformation to enable displacement of the seismic masses 71 in the direction of the arrows D, and hence in a direction basically perpendicular to the barycentric axis G, extend from the shorter sides of the rectangles forming the seismic masses 71, as far as the shorter sides of the rectangle forming the central beam 73. Mobile electrodes 75 extend from the two longer sides of the two rectangles forming the seismic masses 71 and face, each, a pair of fixed electrodes 76, 77. The fixed electrodes 76 are all electrically connected together, and the fixed electrodes 77 are all electrically connected together. The seismic masses 71 and the mobile electrodes 75 form the rotor 80 of the linear accelerometer 70, while the fixed electrodes 76, 77 form the stator 81.

[0038] The central beam 73 is integral with a single anchoring portion 83, dashed in Figure 13 and made in a way similar to the anchoring portion 49 of Figure 11. In particular, the center of the anchoring portion 83 is arranged on the barycentric axis G of the linear accelerometer 70, so that the latter is made largely insensitive to residual stresses and less subject to damage in the fabrication phase, just as was described above with reference to the angular accelerometer 40.

[0039] The angular speed sensor, or gyroscope, 90 of Figure 14 has a central beam 91 supported by a single anchoring portion 92 (shown dashed) on the substrate (not shown), as the anchoring portion 83 of Figure 13. Four first springs 93 similar to the springs 72 of Figure 13 extend from the two shorter sides of the central beam 91, parallel thereto, and four second springs 94 extend at 90° from the first springs 93, connected in couples to respective seismic masses 95. In practice, the first springs 93 and the second springs 94 provide two degrees of freedom to the sensor, which is able to move in a micrometric manner in any direction resulting from the vector sum of the direction of the first and second springs 93, 94, in a plane perpendicular to the barycen-

tric axis G.

[0040] Mobile excitation electrodes 96 extend from the two sides of each seismic mass 95, perpendicularly to the second springs 94, and hence parallel to the first springs 93. The mobile excitation electrodes 96 are arranged interleaved with fixed excitation electrodes 97.

[0041] In addition, mobile sensing electrodes 98 extend from the two sides of each second spring 94 and are perpendicular to the second springs 94 and hence parallel to the first springs 93. The sensing electrodes 98 are arranged interleaved with fixed sensing electrodes 99 for detecting the Coriolis force.

[0042] Like the linear accelerator 70 of Figure 13, also the angular speed sensor 90 of Figure 14 thus has a single anchoring region 92 arranged along the barycentric axis G of the structure, and consequently presents the advantages described above.

[0043] Finally, it is clear that numerous modifications and variations may be made to the micro-electromechanical structures described and illustrated herein, all falling within the scope of the invention as defined in the attached claims. In particular, it is emphasized that the invention is applicable to all microstructures that may be made using microelectronic techniques and are equipped with suspended masses arranged in a remote position from the center of gravity, irrespective of the type of microstructure, the type of machining (epitaxial, surface, or bulk micromachining) and of the material used (monocrystalline or polycrystalline silicon, either grown or deposited, or metallic materials).

Claims

1. A microelectromechanical structure (40; 70; 90) comprising a rotor element (22; 80) having a barycentric axis (G) and including suspended regions (25; 71; 95) arranged at a distance with respect to said barycentric axis, characterized in that said rotor element (22; 80) is connected to a single anchoring portion (49; 73; 92) extending along said barycentric axis (G).

2. The microelectromechanical structure according to Claim 1, characterized in that said single anchoring portion (49; 73; 92) is integral with a body (41) of semiconductor material.

3. The microelectromechanical structure according to Claim 1 or Claim 2, characterized by an angular accelerometer (40), and in that said rotor element (22) comprises a suspended mass (25) of annular shape concentric with said barycentric axis (G) and connected to said single anchoring portion (49) through a suspension structure (30, 45), said suspended mass (25) bearing a plurality of mobile electrodes (26) extending radially towards said barycentric axis (G) and interleaved with a plurality of fixed elec-

trodes (27, 28).

4. The microelectromechanical structure according to Claim 3, characterized in that said suspension structure (30, 45) comprises suspended arms extending radially, at a uniform distance from each other, from said suspended mass (25) towards a central anchoring element (45) integral with said anchoring portion (49), said anchoring portion being integral with a substrate (51) of semiconductor material.

5. The microelectromechanical structure according to Claim 4, characterized in that said central anchoring element (45) is in electrical contact, through said anchoring portion (49), with an electrical connection region (50a) extending over said substrate (51) and beneath said rotor element (22); said electrical connection region (50a) being isolated from said rotor element by an air gap region (60).

6. The microelectromechanical structure according to Claim 1 or Claim 2, characterized in that said rotor element (80) comprises a pair of seismic masses (71; 95) extending at a distance from each other on opposite sides of said barycentric axis (G) and connected to said single anchoring portion (83; 92) through a suspension structure (72, 73; 91, 93, 94), each said seismic mass (71; 95) bearing two pluralities of first mobile electrodes (75; 96), each plurality of first mobile electrodes extending from a different side of a respective seismic mass (71; 95) and being interleaved with a respective first plurality of fixed electrodes (76; 97).

7. The microelectromechanical structure according to Claim 6, characterized in that said suspension structure (72, 73; 91, 93, 94) comprises first spring elements (72; 93) extending perpendicularly to said seismic masses (71; 95) towards a central anchoring element (73; 91) contiguous to said anchoring portion (83; 92), said anchoring portion being integral with a substrate of semiconductor material.

8. The microelectromechanical structure according to Claim 7, characterized in that said central anchoring element (73; 91) is a beam element extending parallel to said seismic masses (71; 95).

9. The microelectromechanical structure according to any of Claims 6-8, characterized in that it comprises a linear accelerometer (70).

10. The microelectromechanical structure according to any of Claims 6-8, characterized in that it comprises a gyroscope (90) .

11. The microelectromechanical structure according to

Claim 10, characterized in that said suspension structure (91, 93, 94) comprises second spring elements (94) extending perpendicularly to said first spring elements (93) between said first spring elements (93) and said seismic masses (95); each said second spring element (94) bearing two pluralities of second mobile electrodes (98), each plurality of second mobile electrodes (98) extending from a different side of a respective second spring element (94) and being interleaved with a respective second plurality of fixed electrodes (99).

12. The microelectromechanical structure according to any one of the foregoing claims, characterized in that said rotor element (22; 80) is of semiconductor material.
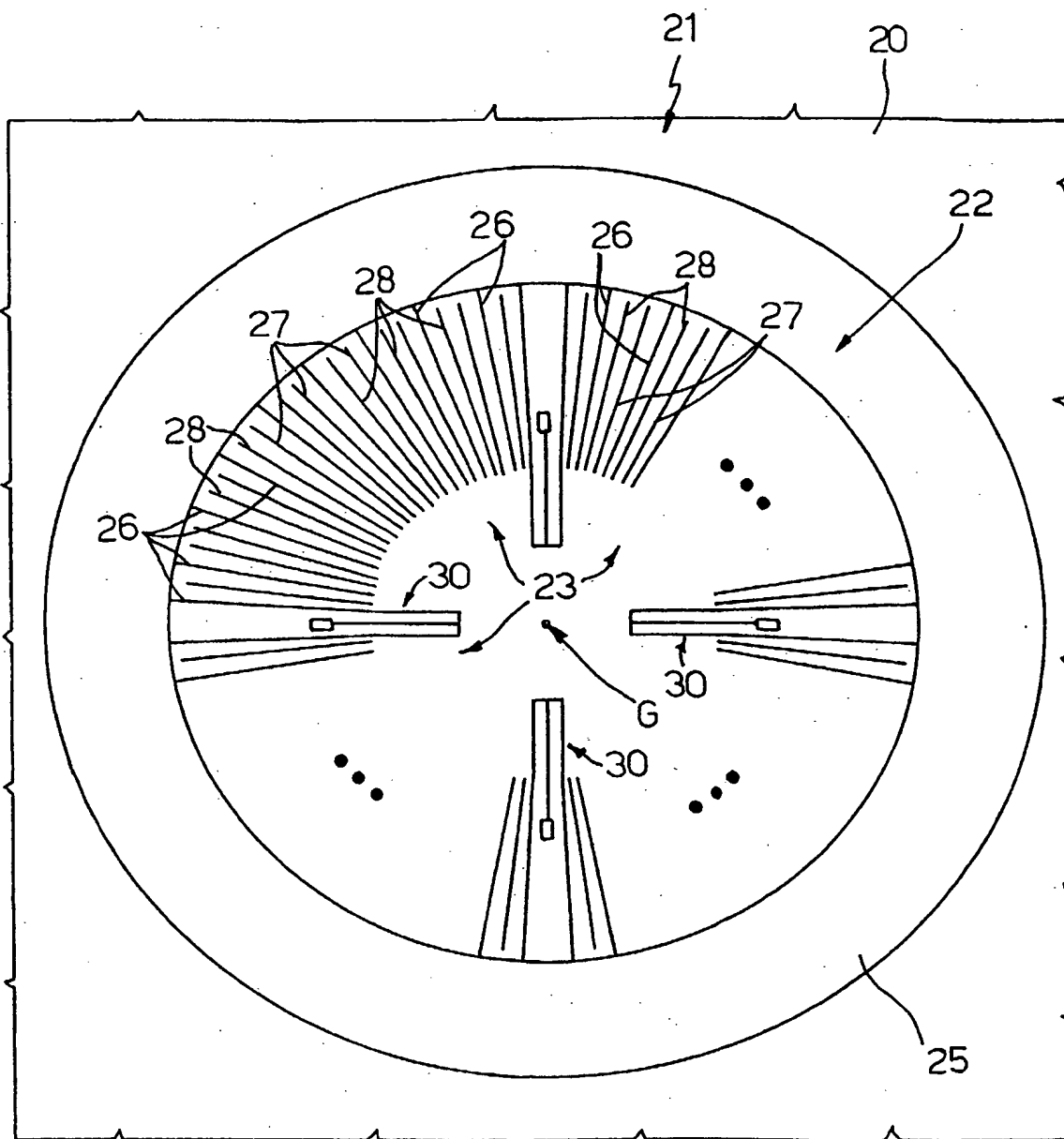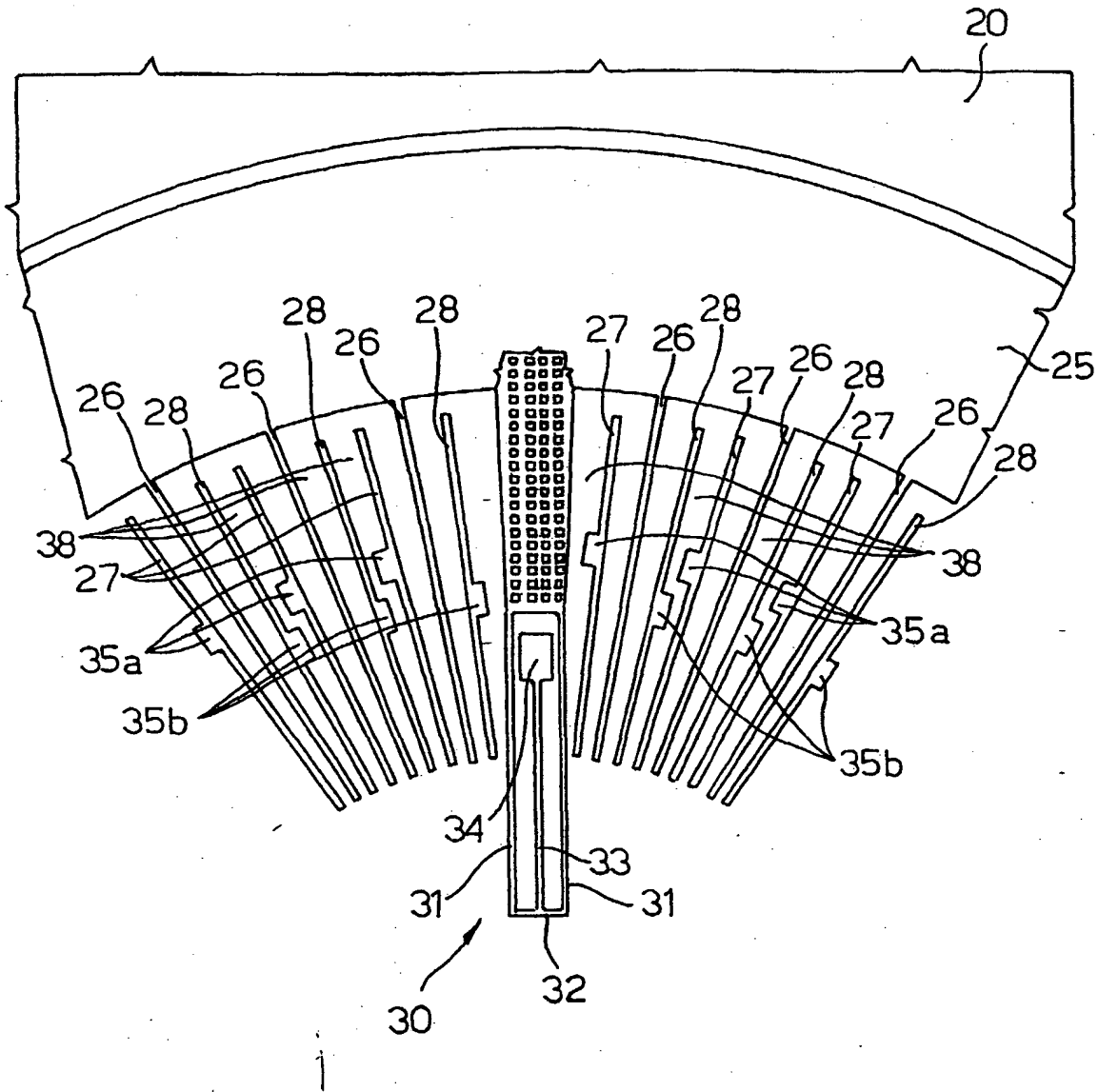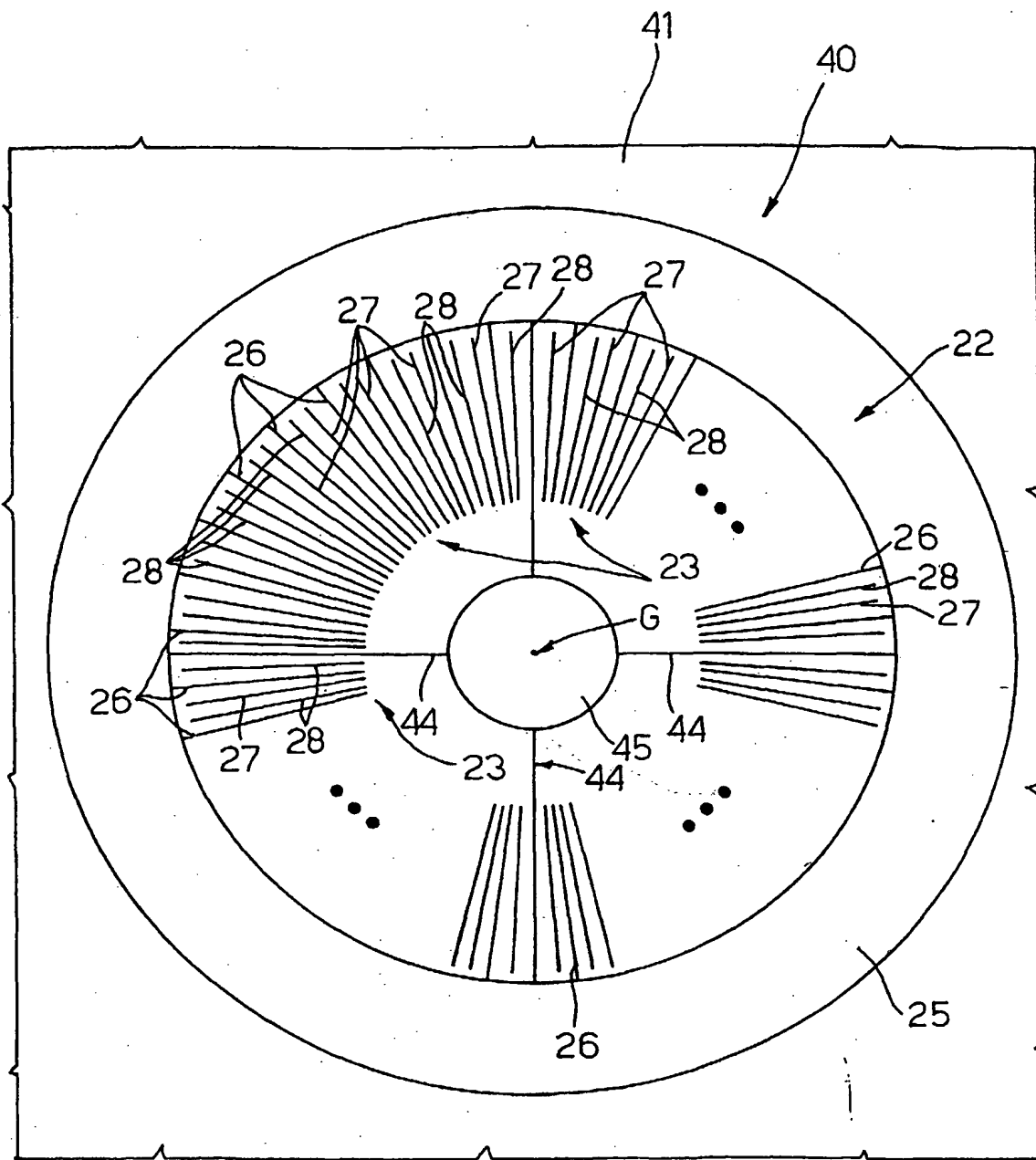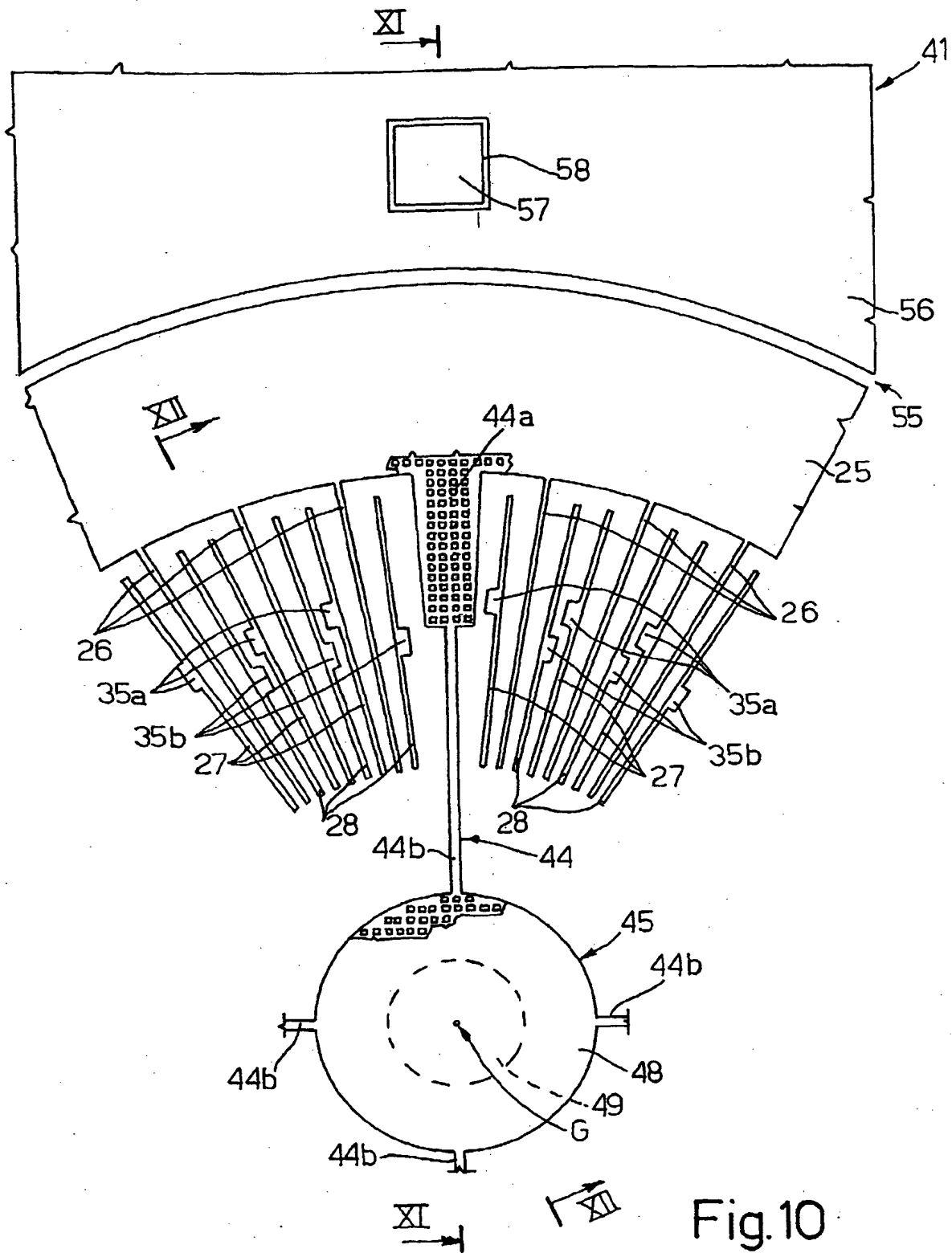
Fig.1

Fig.2

Fig.3

Fig.4

Fig.5

Fig.6

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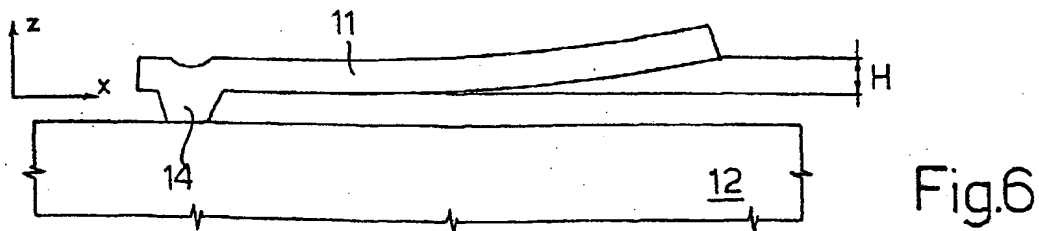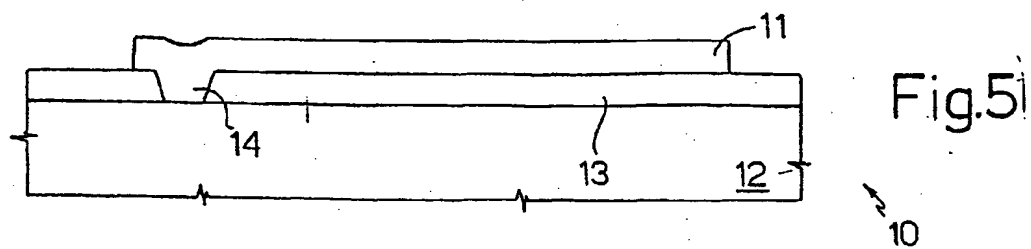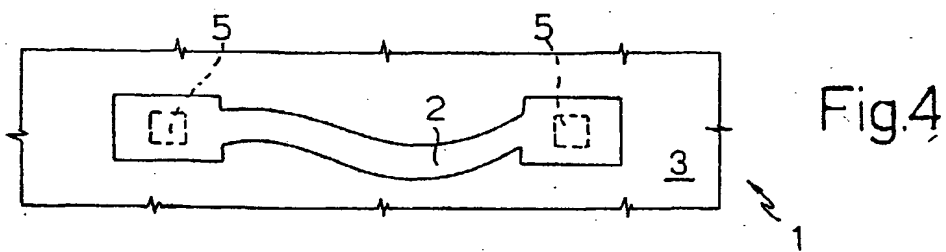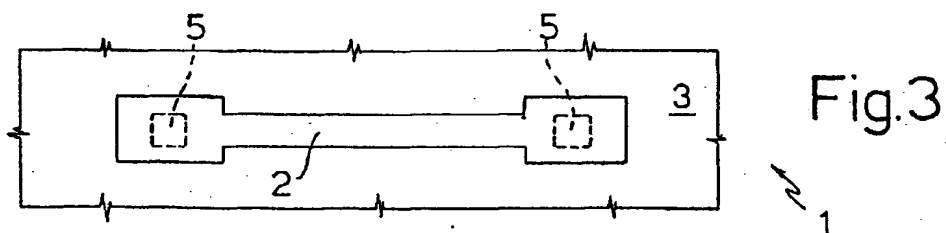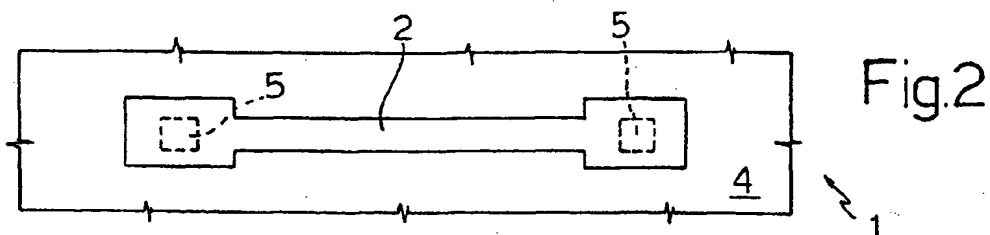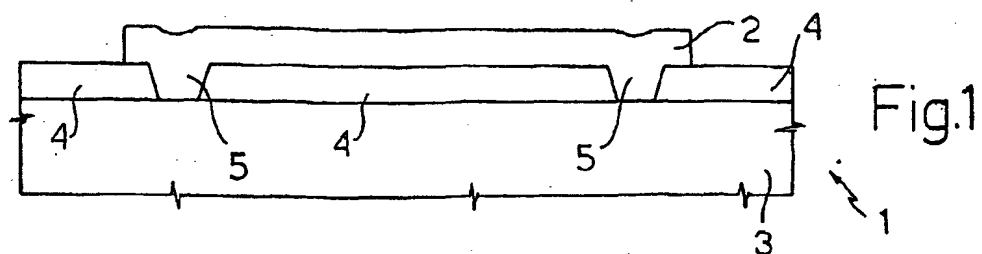
Fig.7

Fig. 8

Fig.9

Fig.10
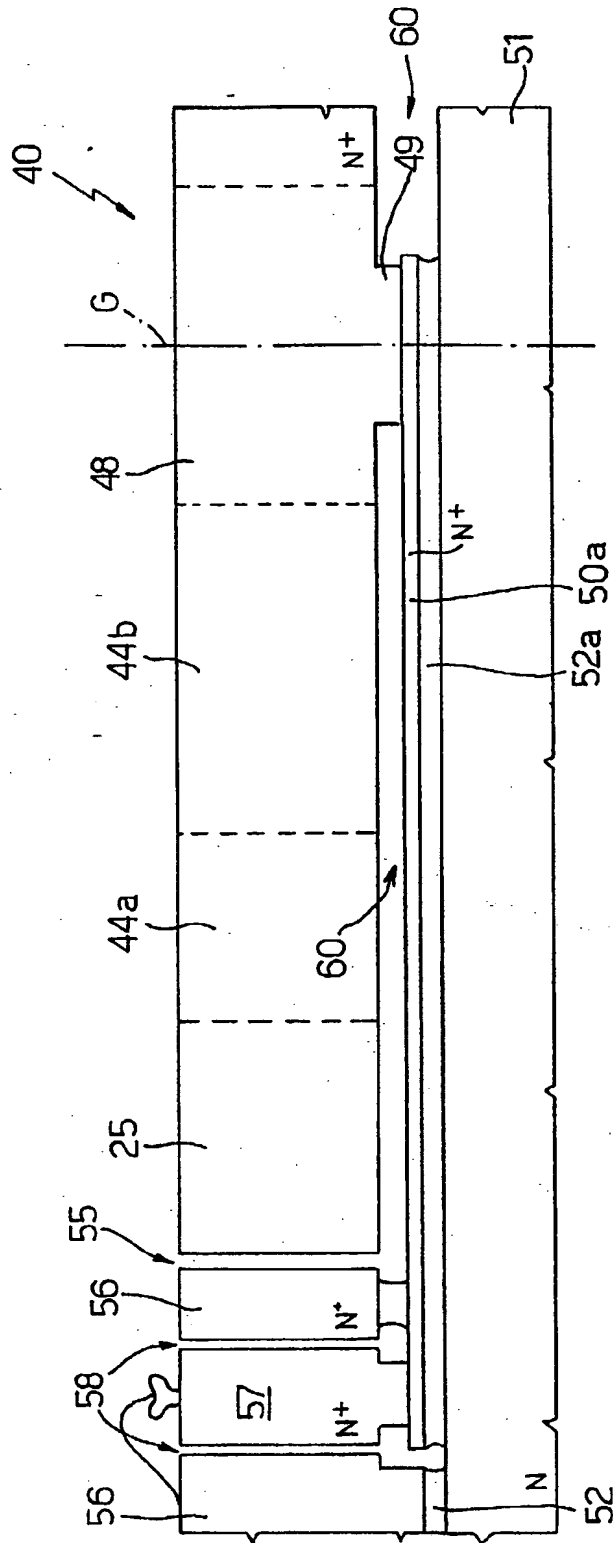
Fig.11

Fig.12

Fig.13

Fig.14

EUROPEAN SEARCH REPORT

European Patent Office

Application Number

EP 99 83 0565

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	EP 0 564 186 A (HEWLETT PACKARD CO) 6 October 1993 (1993-10-06) * figures 1,2 * * column 3, line 23 - line 35 * * column 4, line 37 - line 55 *	1,2,12	B81B5/00 B81B3/00 G01P15/135 G01P15/125 G01P15/08 G01C19/56
Y		3	
A		4-11	

X	TANG W C ET AL: "LATERALLY DRIVEN POLYSILICON RESONANT MICROSTRUCTURES" SENSORS AND ACTUATORS,CH,ELSEVIER SEQUOIA S.A. LAUSANNE, vol. 20, no. 1 / 02, page 25-32 XP000135244 * figures 1-3,5-9 * * paragraph [03.2] *	1,2,12	
Y		3	
A		4-11	

X	US 5 233 874 A (PUTTY MICHAEL W ET AL) 10 August 1993 (1993-08-10) * figures 1-4 * * column 6, line 11 - column 7, line 14 *	1,2,12	**TECHNICAL FIELDS SEARCHED (Int.Cl.7)** B81B G01P G01C
A		3-11	

X	WO 96 35957 A (DRAPER LAB CHARLES S) 14 November 1996 (1996-11-14) * figures 7,10 * * page 4, line 20 - line 28 * * page 21, line 36 - page 22, line 36 * * page 31, line 26 - line 36 *	1,2,12	
A		3-11	

X	US 5 233 213 A (MAREK JIRI) 3 August 1993 (1993-08-03) * figures 5,6 * * column 5, line 30 - column 6, line 7 *	1,2,12	
A		3-11	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	19 January 2000	Polesello, P

EPO FORM 1503 03.82 (P04C01)
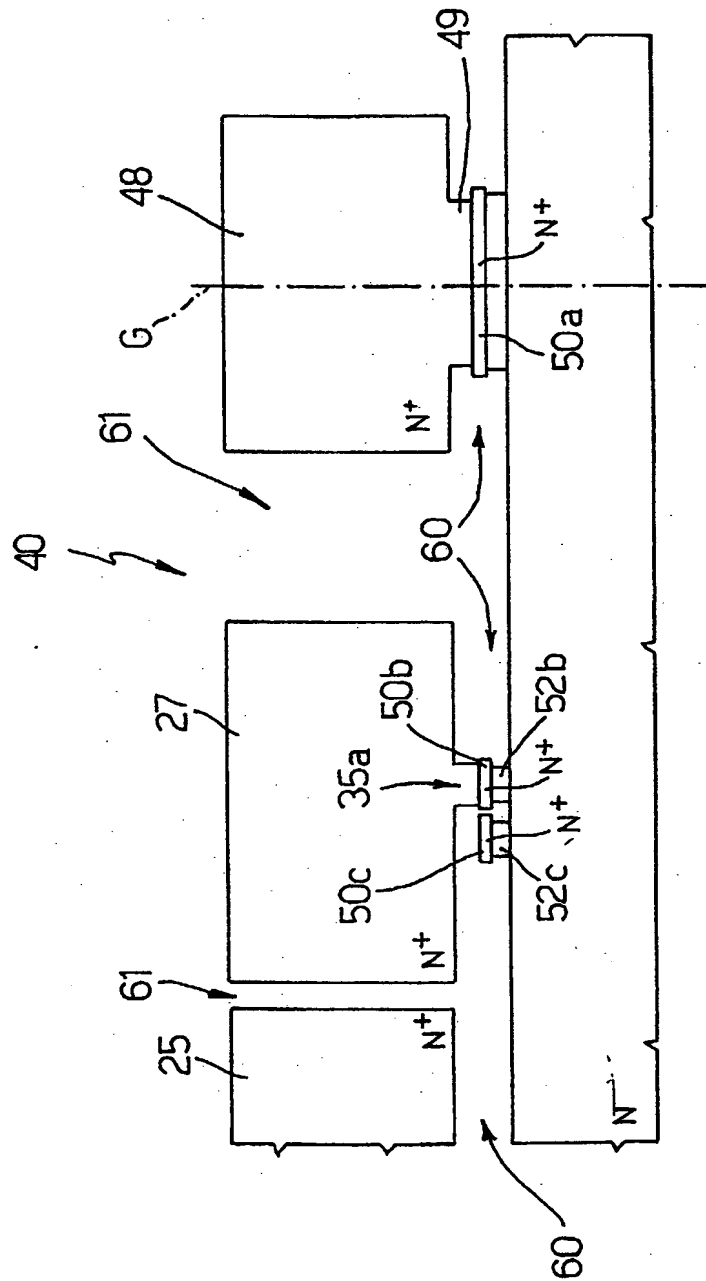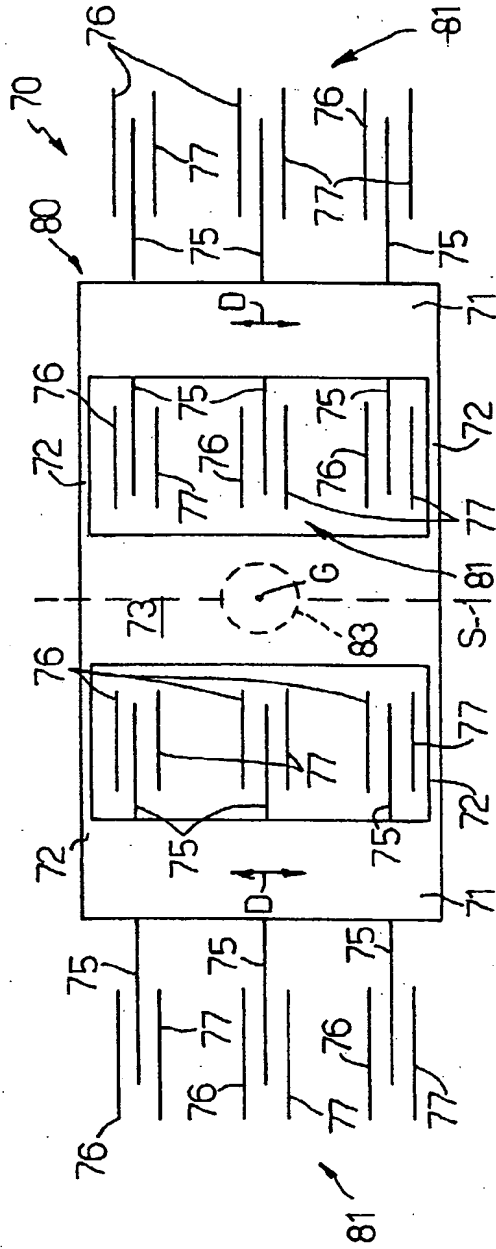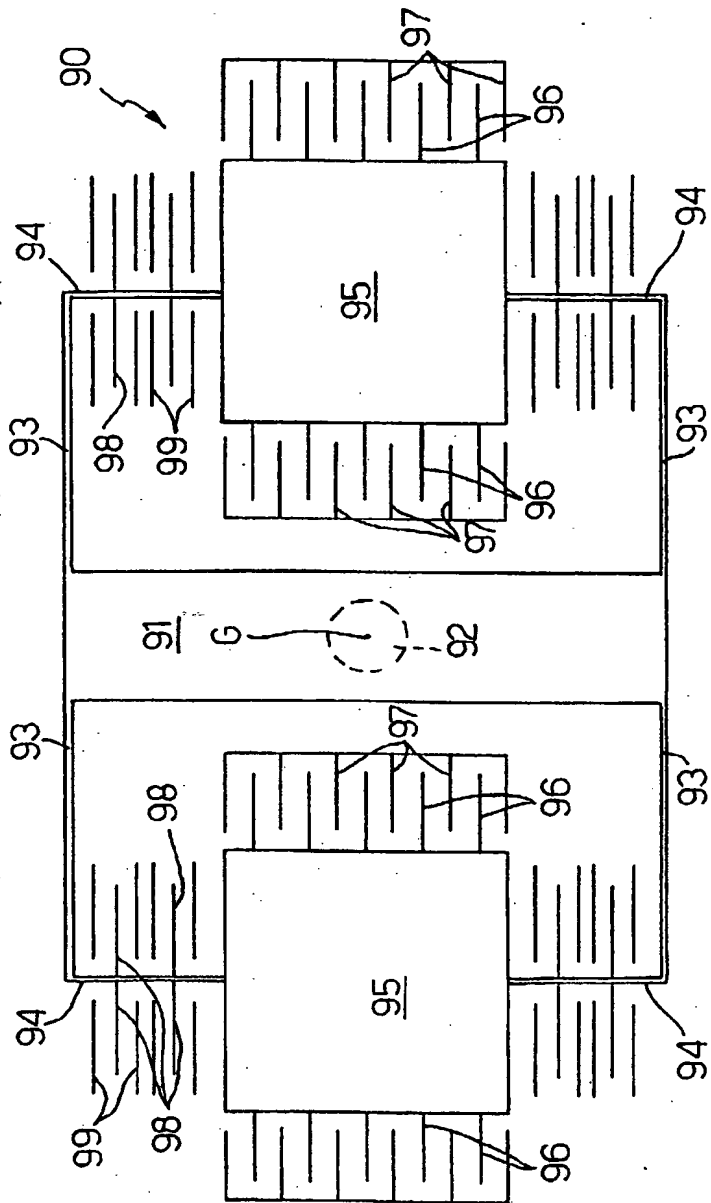
16

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 99 83 0565

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	EP 0 623 807 A (GEN MOTORS CORP) 9 November 1994 (1994-11-09) * figures 1A,1B * * column 3, line 22 - line 33 * * column 4, line 39 - line 52 *	1,2,12	
A		3-11	
X	EP 0 578 228 A (MATSUSHITA ELECTRIC IND CO LTD) 12 January 1994 (1994-01-12) * figures 1,2,10,12-14,34 * * column 9, line 6 - line 28 * * column 11, line 56 - column 12, line 40 * * column 20, line 27 - column 21, line 20 *	1,2,12	
A		3-11	
X	US 5 441 300 A (YOKOTA YOSHIHIRO ET AL) 15 August 1995 (1995-08-15) * figures 1-4,7,8,17,18 * * column 2, line 54 - column 3, line 6 * * column 3, line 46 - line 66 * * column 4, line 29 - line 35 *	1,12	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
A		2-11	
A	EP 0 911 606 A (ST MICROELECTRONICS SRL) 28 April 1999 (1999-04-28) * figures 1-4 * * paragraphs [0010]-[0014] *	1-12	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	19 January 2000	Polesello, P

CATEGORY OF CITED DOCUMENTS

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EP 99 83 0565

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19-01-2000

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
EP 0564186	A	06-10-1993	US 5251484 A DE 69310260 D DE 69310260 T JP 6018551 A		12-10-1993 05-06-1997 14-08-1997 25-01-1994
US 5233874	A	10-08-1993	NONE		
WO 9635957	A	14-11-1996	US 5650568 A CA 2220773 A EP 0824702 A JP 11505021 T		22-07-1997 14-11-1996 25-02-1998 11-05-1999
US 5233213	A	03-08-1993	DE 4022464 A CH 684029 A GB 2246635 A,B JP 4232875 A		16-01-1992 30-06-1994 05-02-1992 21-08-1992
EP 0623807	A	09-11-1994	US 5450751 A DE 69411990 D DE 69411990 T JP 7012575 A		19-09-1995 03-09-1998 10-12-1998 17-01-1995
EP 0578228	A	12-01-1994	JP 6231548 A JP 6038562 A JP 6178565 A JP 6201369 A DE 69314708 D DE 69314708 T		19-08-1994 10-02-1994 24-06-1994 19-07-1994 27-11-1997 19-02-1998
US 5441300	A	15-08-1995	JP 2773495 B JP 5142249 A US 5707077 A		09-07-1998 08-06-1993 13-01-1998
EP 0911606	A	28-04-1999	EP 0922944 A JP 11150096 A		16-06-1999 02-06-1999

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82